

WHAT IS CLAIMED IS:

1. An image-forming apparatus comprising:

at least one image-forming section that has an exposing unit and a developing unit, said at least one image-forming section printing an image of a density detection pattern having a plurality of pattern segments of different duties, the image being printed on a print medium under a predetermined printing condition;

a density detector that outputs detection values indicative of densities of the plurality of pattern segments printed on the print medium; and

a controller that determines a correction value based on the detection values and corresponding target values to modify the printing condition.

2. The image-forming apparatus according to Claim 1, wherein said at least one image-forming section is one of a plurality of image-forming sections that print images of different colors.

3. The image-forming apparatus according to Claim 1 wherein said controller controls said image-forming section and said density detector to perform:

a first density detection operation in which said at least one image-forming section forms the image of density detection pattern with a first printing condition, and then said controller calculates a first correction value based on the density of the plurality of pattern segments detected by said density detector, said controller producing a second printing condition using the correction value; and

a second density detection operation in which the image-forming section forms the image of density detection pattern with the second printing condition, and then said controller calculates a second correction value based on the density of the plurality of pattern segments detected by said density detector, said controller

producing a second printing condition using the second correction value.

4. The image-forming apparatus according to Claim 3, wherein the plurality of pattern segments include a low duty segment, a medium duty segment, and a high duty segment;

wherein the low duty segment has a density not more than 50%, the medium duty segment has a density in the range of 30 to 80%, and the high duty segment has a density not less than 60%;

wherein densities of the low, medium, and high duty segments are related such that $D_L < D_M < D_H$ where D_L is the density in the low duty, D_M is the density in the medium duty, and D_H is the density in the high duty.

5. The image-forming apparatus according to Claim 4, wherein the first correction value indicates a correction to an amount of light emitted from the exposing unit and the second correction value indicates a correction to a developing voltage applied to the developing unit,

wherein the first correction value is calculated by Equation (1) and the second correction value is calculated by Equation (3),

$$C1 = (1/2) \{D_H \times (T_L/T_H) - D_L\} / K1 + (1/2) \{D_H \times (T_M/T_H) - D_M\} / K2 \quad \cdots \cdots (1)$$

$$Cv = (1/3) (T_L - D_L) / K3 + (1/3) (T_M - D_M) / K4 + (1/3) (T_H - D_H) / K5 \quad \cdots \cdots (3)$$

where $C1$ is the first correction value,

Cv is the second correction value,

D_H is a density at a high duty not less than 60%,

D_M is a detected density at a medium duty in the range of 30 to 80%,

D_L is a density at a low duty not more than 50%,

T_H is a target density at the high duty,

T_M is a target density at the medium duty,

T_L is a detected density at the low duty,

$K1$ is a rate of change of D_L per unit change of the amount of light emitted from the exposing unit,

$K2$ is a rate of change of D_M per unit change of the amount of light

emitted from the exposing unit,

K3 is a unit change of D_L per unit change of the developing voltage,

K4 is a unit change of D_M per unit change of the developing voltage,

K5 is a unit change of D_H per unit change of the developing voltage,

and

D_L , D_M , and D_H are related such that $D_L < D_M < D_H$.

6. The image-forming apparatus according to Claim 5, wherein the detected detection values are sent to a host apparatus.

7. The image-forming apparatus according to Claim 3, wherein the plurality of pattern segments include a low duty segment and a medium duty segment;

wherein the low duty segment has a density not more than 50% and the medium duty segment has a density in the range of 30 to 80%;

wherein densities of the low duty and the medium duty segments are related such that $D_L < D_M$ where D_L is the density in the low duty, and D_M is the density in the medium duty.

8. The image-forming apparatus according to Claim 7, wherein the first correction value indicates a correction to an amount of light emitted from the exposing unit and the second correction value indicates a correction to a developing voltage applied to the developing unit,

wherein the first correction value is calculated by Equation (4) and the second correction value is calculated by Equation (5),

$$C1 = (1/2) \{ (T_L - D_L) / K1 + (T_M - D_M) / K2 \} \dots (4)$$

$$Cv = (1/2) \{ (T_L - D_L) / K3 + (T_M - D_M) / K4 \} \dots (5)$$

where C1 is the first correction value,

Cv is the second correction value,

D_H is a density at the high duty,

D_M is a detected density at the medium duty,

D_L is a density at the low duty,

T_H is a target density at the high duty,

T_M is a target density at the medium duty,
 T_L is a detected density at the low duty,
 $K1$ is a rate of change of D_L per unit change of the amount of light emitted from the exposing unit,
 $K2$ is a rate of change of D_M per unit change of the amount of light emitted from the exposing unit,
 $K3$ is a unit change of D_L per unit change of the developing voltage,
 $K4$ is a unit change of D_M per unit change of the developing voltage,
 $K5$ is a unit change of D_H per unit change of the developing voltage,
 and
 D_L , D_M , and D_H are related such that $D_L < D_M < D_H$.

9. The image-forming apparatus according to Claim 7, wherein the first correction value indicates a correction to an amount of light emitted from the exposing unit and the second correction value indicates a correction to a developing voltage applied to the developing unit,

wherein the first correction value being calculated by Equation (6) and the second correction value being calculated by Equation (7).

$$C1 = (1/(W1+W2)) \{D_H \times (T_L/T_H) - D_L\} \times W1/K1 + (1/(W1+W2)) \{D_H \times (T_M/T_H) - D_M\} \times W2/K2 \quad \dots (6)$$

$$Cv = \{ (T_L - D_L) \times W3/K3 + (T_M - D_M) \times W4/K4 + (T_H - D_H) \times W5/K5 \} / (W3 + W4 + W5) \quad \dots (7)$$

where $C1$ is the first correction value,

Cv is the second correction value,

D_H is a density at the high duty,

D_M is a detected density at the medium duty,

D_L is a density at the low duty,

T_H is a target density at the high duty,

T_M is a target density at the medium duty,

T_L is a detected density at the low duty,

$K1$ is a rate of change of D_L per unit change of the amount of light emitted from the exposing unit,

K2 is a rate of change of D_M per unit change of the amount of light emitted from the exposing unit,

K3 is a unit change of D_L per unit change of the developing voltage,

K4 is a unit change of D_M per unit change of the developing voltage,

K5 is a unit change of D_H per unit change of the developing voltage,

D_L , D_M , and D_H are related such that $D_L < D_M < D_H$,

W1 is a weight used for correcting the amount of light in the low duty,

W2 is a weight used for correcting the amount of light in the medium duty,

W1 and W2 are related such that $W1 \geq W2$, and

W3, W4, and W5 are weights used for correcting the developing voltages in the low, medium, and high duties, respectively, and W3, W4, and W5 are related such that $W3 \geq W4 \geq W5$.

10. The image-forming apparatus according to Claim 1, wherein said controller controls said image-forming section and said density detector to perform:

a first density detection operation in which said at least one image-forming section forms the image of density detection pattern with a printing condition, and then said controller calculates a correction value based on the density of the plurality of pattern segments detected by said density detector.

11. The image-forming apparatus according to Claim 10, wherein the plurality of pattern segments include a low duty segment, a medium duty segment, and a high duty segment;

wherein the low duty segment has a density not more than 50%, the medium duty segment has a density in the range of 30 to 80%, and the high duty segment has a density not less than 60%;

wherein densities of the low, medium, and high duty segments are related such that $D_L < D_M < D_H$ where D_L is the density in the low duty, D_M is the density in the medium duty, and D_H is the density in the high duty.

12. The image-forming apparatus according to Claim 11, wherein the first correction value indicates a correction to an amount of light emitted from the exposing unit and the second correction value indicates a correction to a developing voltage applied to the developing unit,

wherein the first correction value being calculated by Equation (1) and the second correction value being calculated by Equation (2);

$$C1 = (1/2) \{D_H \times (T_L/T_H) - D_L\} / K1 + (1/2) \{D_H \times (T_M/T_H) - D_M\} / K2 \quad \cdots \cdots (1)$$

$$Cv = (1/3) \{T_L - (D_L + \Delta L \times K1)\} / K3 + (1/3) \{T_M - (D_M + \Delta L \times K2)\} / K4 + (1/3) \{T_H - D_H\} / K5 \quad \cdots \cdots (2)$$

where C1 is the first correction value,

Cv is the second correction value,

D_H is a density at the high duty,

D_M is a detected density at the medium duty,

D_L is a density at the low duty,

ΔL is a change of amount of light,

T_H is a target density at the high duty,

T_M is a target density at the medium duty,

T_L is a detected density at the low duty,

K1 is a rate of change of D_L per unit change of the amount of light emitted from the exposing unit,

K2 is a rate of change of D_M per unit change of the amount of light emitted from the exposing unit,

K3 is a unit change of D_L per unit change of the developing voltage,

K4 is a unit change of D_M per unit change of the developing voltage,

K5 is a unit change of D_H per unit change of the developing voltage, and

D_L , D_M , and D_H are related such that $D_L < D_M < D_H$.

13. The image-forming apparatus according to Claim 1, wherein the energy for the developing section to develop the latent image is at least one of a developing voltage applied to a developing roller,

a supply voltage applied to a toner supplying roller, and a charging voltage applied to a charging roller.

14. The image-forming apparatus according to Claim 1, wherein the energy for the latent image-forming section is an amount of light emitted from either an LED or a laser.